

# Automotive 750 V, 950 A Single Side Direct Cooling 6-Pack Power Module

**VE-Tract<sup>™</sup> Direct Module**

**NVH950S75L4SPC**

## Product Description

The NVH950S75L4SPC is a power module from the VE-Tract<sup>™</sup> Direct family of highly integrated power modules with industry standard footprints for Hybrid (HEV) and Electric Vehicle (EV) traction inverter application.

The module integrates six Field Stop 4 (FS4) 750 V Narrow Mesa IGBTs in a 6-pack configuration, which excels in providing high current density, while offering robust short circuit protection and increased blocking voltage. Additionally, FS4 750 V Narrow Mesa IGBTs show low power losses during lighter loads, which helps to improve overall system efficiency in automotive applications.

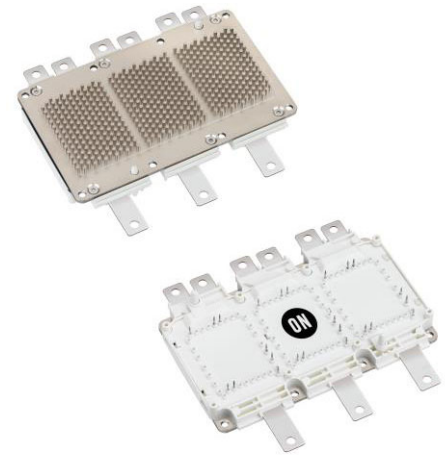
For assembly ease and reliability, a new generation of press-fit pins are integrated into the power module signal terminals. In addition, the power module has an optimized pin-fin heatsink in the baseplate and longer power terminals to easily integrate an external current sensor.

## Features

- Direct Cooling w/ Integrated Pin-fin Heatsink
- Ultra-low Stray Inductance
- $T_{vjmax} = 175^{\circ}\text{C}$  Continuous Operation
- Low  $V_{CESAT}$  and Switching Losses
- Automotive Grade FS4 750 V Narrow Mesa IGBT
- Fast Recovery Diode Chip Technologies
- 4.2 kV Isolated DBC Substrate
- Easy to Integrate 6-pack Topology
- This Device is Pb-Free and is RoHS Compliant

## Typical Applications

- Hybrid and Electric Vehicle Traction Inverter
- High Power Converters

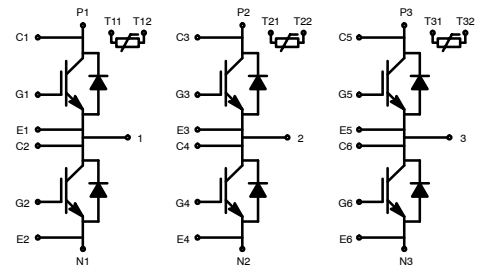


**SSDC33, 154.50x92.0 (SPC)  
CASE 183AC**

## MARKING DIAGRAM

XXXXXXXXXXXXXXXXXXXXX  
ATYYWW

XXXXX = Specific Device Code  
AT = Assembly & Test Site Code  
YYWW = Year and Work Week Code



## ORDERING INFORMATION

See detailed ordering and shipping information on page 5 of this data sheet.

# NVH950S75L4SPC

## Pin Description

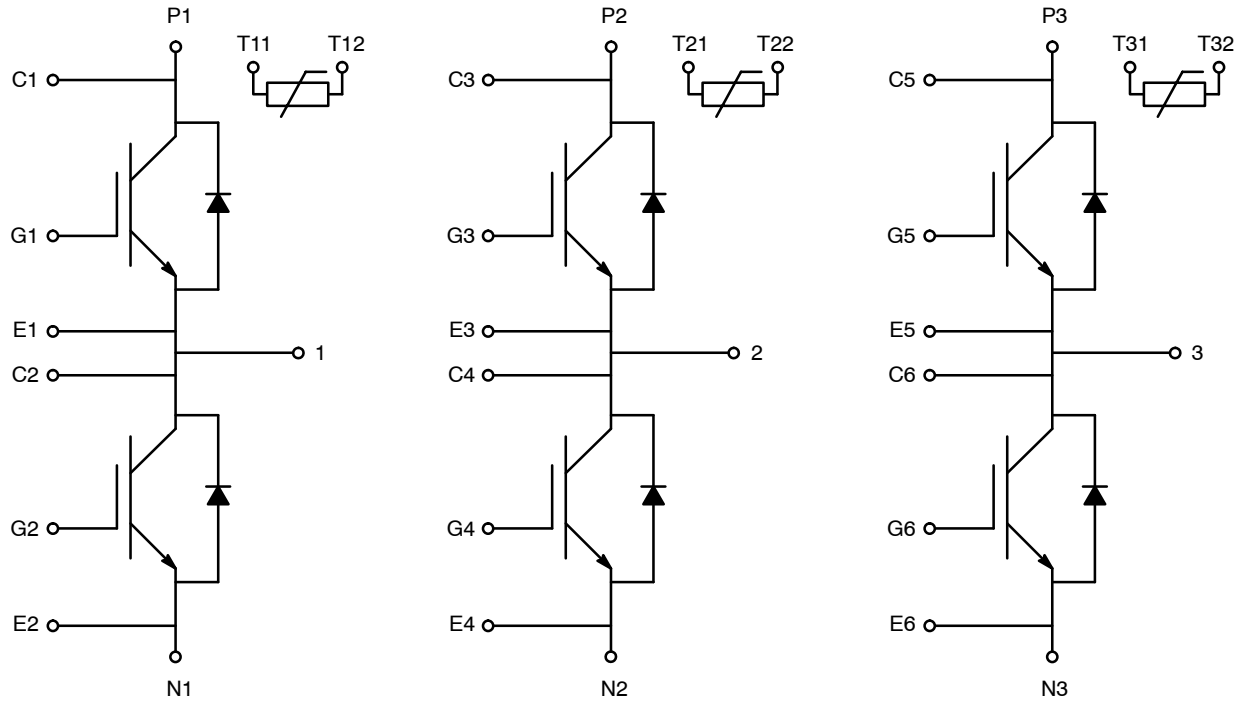


Figure 1. Pin Description

## PIN FUNCTION DESCRIPTION

| Pin #      | Pin Function Description          |
|------------|-----------------------------------|
| P1, P2, P3 | Positive Power Terminals          |
| N1, N2, N3 | Negative Power Terminals          |
| 1          | Phase 1 Output                    |
| 2          | Phase 2 Output                    |
| 3          | Phase 3 Output                    |
| G1–G6      | IGBT Gate                         |
| E1–E6      | IGBT Gate Return                  |
| C1–C6      | Desat Detect/Collector Sense      |
| T11, T12   | Phase 1 Temperature Sensor Output |
| T21, T22   | Phase 2 Temperature Sensor Output |
| T31, T32   | Phase 3 Temperature Sensor Output |

## Materials

DBC Substrate: SiN isolated substrate, basic isolation,  
and copper on both sides

Terminals: Copper + Tin electro-plating

Signal Leads: Copper + Tin plating

Pin-fin Base plate: Copper + Ni plating

## Flammability Information

The module frame meets UL94V-0 flammability rating.

# NVH950S75L4SPC

## MODULE CHARACTERISTICS (T<sub>vj</sub> = 25°C, Unless Otherwise Specified)

| Symbol             | Parameter                                               | Rating     | Unit |
|--------------------|---------------------------------------------------------|------------|------|
| T <sub>vj</sub>    | Operating Junction Temperature                          | –40 to 175 | °C   |
| T <sub>STG</sub>   | Storage Temperature                                     | –40 to 125 | °C   |
| V <sub>ISO</sub>   | Isolation Voltage (DC, 0 Hz, 1 s)                       | 4200       | V    |
| L <sub>sCE</sub>   | Stray Inductance                                        | 8          | nH   |
| RCC'+EE'           | Module Lead Resistance, Terminals – Chip                | 0.75       | mΩ   |
| G                  | Module Weight                                           | 700        | g    |
| CTI                | Comparative Tracking Index                              | >200       | –    |
| d <sub>creep</sub> | Creepage: Terminal to Heatsink<br>Terminal to Terminal  | 9.0<br>9.0 | mm   |
| d <sub>clear</sub> | Clearance: Terminal to Heatsink<br>Terminal to Terminal | 4.5<br>4.5 | mm   |

| Symbol     | Parameters                                  | Conditions                                                     | Min    | Typ    | Max        | Unit |
|------------|---------------------------------------------|----------------------------------------------------------------|--------|--------|------------|------|
| Δp         | Pressure Drop in Cooling Circuit            | 10 L/min, 65°C, 50/50 EGW                                      | –      | 95     | –          | mbar |
| P (Note 1) | Maximum Pressure in Cooling Loop (relative) | T <sub>Baseplate</sub> < 40°C<br>T <sub>Baseplate</sub> > 40°C | –<br>– | –<br>– | 2.5<br>2.0 | bar  |

1. EPDM rubber 50 durometer 'O' ring used.

## ABSOLUTE MAXIMUM RATINGS (T<sub>vj</sub> = 25°C, Unless Otherwise Specified)

| Symbol | Parameter | Rating | Unit |
|--------|-----------|--------|------|
|--------|-----------|--------|------|

### IGBT

|                    |                                                                                                |              |   |
|--------------------|------------------------------------------------------------------------------------------------|--------------|---|
| V <sub>CES</sub>   | Collector to Emitter Voltage                                                                   | 750          | V |
| V <sub>GES</sub>   | Gate to Emitter Voltage                                                                        | ±20          | V |
| I <sub>CN</sub>    | Implemented Collector Current                                                                  | 950          | A |
| I <sub>C nom</sub> | Continuous DC Collector Current, T <sub>vj</sub> = 175°C, T <sub>F</sub> = 65°C, Ref. Heatsink | 750 (Note 2) | A |
| I <sub>CRM</sub>   | Pulsed Collector Current @ V <sub>GE</sub> = 15 V, t <sub>p</sub> = 1 mS                       | 1900         | A |
| P <sub>tot</sub>   | Total Power Dissipation T <sub>vj</sub> = 175°C, T <sub>F</sub> = 65°C, Ref. Heatsink          | 1325         | W |

### Diode

|                        |                                                                                                         |                |     |
|------------------------|---------------------------------------------------------------------------------------------------------|----------------|-----|
| V <sub>RRM</sub>       | Repetitive Peak Reverse Voltage                                                                         | 750            | V   |
| I <sub>FN</sub>        | Implemented Forward Current                                                                             | 950            | A   |
| I <sub>F</sub>         | Continuous Forward Current, T <sub>vj</sub> = 175°C, T <sub>F</sub> = 65°C, Ref. Heatsink               | 500 (Note 2)   | A   |
| I <sub>FRM</sub>       | Repetitive Peak Forward Current, t <sub>p</sub> = 1 mS                                                  | 1900           | A   |
| I <sup>2</sup> t value | Surge Current Capability, t <sub>p</sub> = 10 mS,<br>T <sub>vj</sub> = 150°C<br>T <sub>vj</sub> = 175°C | 19000<br>16000 | A²s |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

2. Verified by characterization/design, not by test.

# NVH950S75L4SPC

## CHARACTERISTICS OF IGBT ( $T_{vj} = 25^{\circ}\text{C}$ , Unless Otherwise Specified)

| Symbol      | Parameters                                                     | Conditions                                                                                                                                |                                                                                                                                                                                                | Min         | Typ                  | Max            | Unit                |
|-------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------------|----------------|---------------------|
| $V_{CESAT}$ | Collector to Emitter Saturation Voltage (Terminal)             | $V_{GE} = 15\text{ V}$ , $I_C = 600\text{ A}$                                                                                             | $T_{vj} = 25^{\circ}\text{C}$                                                                                                                                                                  | –           | 1.30                 | 1.55           | V                   |
|             | Collector to Emitter Saturation Voltage (Chip)                 | $V_{GE} = 15\text{ V}$ , $I_C = 600\text{ A}$                                                                                             | $T_{vj} = 25^{\circ}\text{C}$<br>$T_{vj} = 150^{\circ}\text{C}$<br>$T_{vj} = 175^{\circ}\text{C}$                                                                                              | –<br>–<br>– | 1.25<br>1.37<br>1.40 | 1.50<br>–<br>– |                     |
|             |                                                                |                                                                                                                                           | $V_{GE} = 15\text{ V}$ , $I_C = 950\text{ A}$                                                                                                                                                  | –<br>–<br>– | 1.47<br>1.71<br>1.77 | –<br>–<br>–    |                     |
| $I_{CES}$   | Collector to Emitter Leakage Current                           | $V_{GE} = 0$ , $V_{CE} = 750\text{ V}$                                                                                                    | $T_{vj} = 25^{\circ}\text{C}$<br>$T_{vj} = 150^{\circ}\text{C}$                                                                                                                                | –<br>–      | –<br>2.0             | 500<br>–       | $\mu\text{A}$<br>mA |
| $I_{GES}$   | Gate – Emitter Leakage Current                                 | $V_{CE} = 0$ , $V_{GE} = \pm 20\text{ V}$                                                                                                 |                                                                                                                                                                                                | –           | –                    | $\pm 300$      | nA                  |
| $V_{th}$    | Threshold Voltage                                              | $V_{CE} = V_{GE}$ , $I_C = 90\text{ mA}$                                                                                                  |                                                                                                                                                                                                | 4.8         | 5.7                  | 6.6            | V                   |
| $Q_G$       | Total Gate Charge                                              | $V_{GE} = -8$ to $15\text{ V}$ , $V_{CE} = 400\text{ V}$                                                                                  |                                                                                                                                                                                                | –           | 2.3                  | –              | $\mu\text{C}$       |
| $R_{Gint}$  | Internal Gate Resistance                                       |                                                                                                                                           |                                                                                                                                                                                                | –           | 1.7                  | –              | $\Omega$            |
| $C_{ies}$   | Input Capacitance                                              | $V_{CE} = 30\text{ V}$ , $V_{GE} = 0\text{ V}$ , $f = 100\text{ kHz}$                                                                     |                                                                                                                                                                                                | –           | 60                   | –              | nF                  |
| $C_{oes}$   | Output Capacitance                                             | $V_{CE} = 30\text{ V}$ , $V_{GE} = 0\text{ V}$ , $f = 100\text{ kHz}$                                                                     |                                                                                                                                                                                                | –           | 1.90                 | –              | nF                  |
| $C_{res}$   | Reverse Transfer Capacitance                                   | $V_{CE} = 30\text{ V}$ , $V_{GE} = 0\text{ V}$ , $f = 100\text{ kHz}$                                                                     |                                                                                                                                                                                                | –           | 0.2                  | –              | nF                  |
| $T_{d,on}$  | Turn On Delay, Inductive Load                                  | $I_C = 600\text{ A}$ , $V_{CE} = 400\text{ V}$ ,<br>$V_{GE} = +15/-8\text{ V}$ ,<br>$R_{g,on} = 4\text{ }\Omega$                          | $T_{vj} = 25^{\circ}\text{C}$<br>$T_{vj} = 150^{\circ}\text{C}$<br>$T_{vj} = 175^{\circ}\text{C}$                                                                                              | –<br>–<br>– | 315<br>320<br>322    | –<br>–<br>–    | nS                  |
| $T_r$       | Rise Time, Inductive Load                                      | $I_C = 600\text{ A}$ , $V_{CE} = 400\text{ V}$ ,<br>$V_{GE} = +15/-8\text{ V}$ ,<br>$R_{g,on} = 4\text{ }\Omega$                          | $T_{vj} = 25^{\circ}\text{C}$<br>$T_{vj} = 150^{\circ}\text{C}$<br>$T_{vj} = 175^{\circ}\text{C}$                                                                                              | –<br>–<br>– | 108<br>127<br>132    | –<br>–<br>–    | nS                  |
| $T_{d,off}$ | Turn Off Delay, Inductive Load                                 | $I_C = 600\text{ A}$ , $V_{CE} = 400\text{ V}$ ,<br>$V_{GE} = +15/-8\text{ V}$ ,<br>$R_{g,off} = 12\text{ }\Omega$                        | $T_{vj} = 25^{\circ}\text{C}$<br>$T_{vj} = 150^{\circ}\text{C}$<br>$T_{vj} = 175^{\circ}\text{C}$                                                                                              | –<br>–<br>– | 1063<br>1196<br>1203 | –<br>–<br>–    | nS                  |
| $T_f$       | Fall Time, Inductive Load                                      | $I_C = 600\text{ A}$ , $V_{CE} = 400\text{ V}$ ,<br>$V_{GE} = +15/-8\text{ V}$ ,<br>$R_{g,off} = 12\text{ }\Omega$                        | $T_{vj} = 25^{\circ}\text{C}$<br>$T_{vj} = 150^{\circ}\text{C}$<br>$T_{vj} = 175^{\circ}\text{C}$                                                                                              | –<br>–<br>– | 85<br>144<br>151     | –<br>–<br>–    | nS                  |
| $E_{ON}$    | Turn-On Switching Loss (Including Diode Reverse Recovery Loss) | $I_C = 600\text{ A}$ , $V_{CE} = 400\text{ V}$ ,<br>$V_{GE} = +15/-8\text{ V}$ ,<br>$L_s = 22\text{ nH}$ , $R_{g,on} = 4\text{ }\Omega$   | $di/dt = 4.6\text{ A/nS}$ ,<br>$T_{vj} = 25^{\circ}\text{C}$<br>$di/dt = 3.9\text{ A/nS}$ ,<br>$T_{vj} = 150^{\circ}\text{C}$<br>$di/dt = 3.6\text{ A/nS}$ ,<br>$T_{vj} = 175^{\circ}\text{C}$ | –<br>–<br>– | 26<br>36<br>38       | –<br>–<br>–    | mJ                  |
| $E_{OFF}$   | Turn-Off Switching Loss                                        | $I_C = 600\text{ A}$ , $V_{CE} = 400\text{ V}$ ,<br>$V_{GE} = +15/-8\text{ V}$ ,<br>$L_s = 22\text{ nH}$ , $R_{g,off} = 12\text{ }\Omega$ | $dv/dt = 2.7\text{ V/nS}$ ,<br>$T_{vj} = 25^{\circ}\text{C}$<br>$dv/dt = 1.9\text{ V/nS}$ ,<br>$T_{vj} = 150^{\circ}\text{C}$<br>$dv/dt = 1.9\text{ V/nS}$ ,<br>$T_{vj} = 175^{\circ}\text{C}$ | –<br>–<br>– | 33<br>46<br>50       | –<br>–<br>–    | mJ                  |
| $E_{SC}$    | Minimum Short Circuit Energy Withstand                         | $V_{GE} = 15\text{ V}$ , $V_{CC} = 400\text{ V}$                                                                                          | $T_{vj} = 25^{\circ}\text{C}$<br>$T_{vj} = 175^{\circ}\text{C}$                                                                                                                                | 9<br>4.5    | –                    | –              | J                   |

# NVH950S75L4SPC

## CHARACTERISTICS OF INVERSE DIODE ( $T_{vj} = 25^{\circ}\text{C}$ , Unless Otherwise Specified)

| Symbol   | Parameters                       | Conditions                                                                                          |                                                                                                                                                                                                | Min         | Typ                  | Max         | Unit          |
|----------|----------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------------|-------------|---------------|
| $V_F$    | Diode Forward Voltage (Terminal) | $I_F = 600\text{ A}$                                                                                | $T_{vj} = 25^{\circ}\text{C}$                                                                                                                                                                  | –           | 1.70                 | 1.95        | V             |
|          | Diode Forward Voltage (Chip)     | $I_F = 600\text{ A}$                                                                                | $T_{vj} = 25^{\circ}\text{C}$                                                                                                                                                                  | –           | 1.60                 | 1.85        |               |
|          |                                  |                                                                                                     | $T_{vj} = 150^{\circ}\text{C}$<br>$T_{vj} = 175^{\circ}\text{C}$                                                                                                                               | –<br>–      | 1.55<br>1.50         | –<br>–      |               |
|          |                                  | $I_F = 950\text{ A}$                                                                                | $T_{vj} = 25^{\circ}\text{C}$<br>$T_{vj} = 150^{\circ}\text{C}$<br>$T_{vj} = 175^{\circ}\text{C}$                                                                                              | –<br>–<br>– | 1.73<br>1.75<br>1.74 | –<br>–<br>– |               |
| $E_{rr}$ | Reverse Recovery Energy          | $I_F = 600\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$V_{GE} = -8\text{ V}$ ,<br>$R_{g.on} = 4\ \Omega$ | $di/dt = 3.5\text{ A/nS}$ ,<br>$T_{vj} = 25^{\circ}\text{C}$<br>$di/dt = 3.0\text{ A/nS}$ ,<br>$T_{vj} = 150^{\circ}\text{C}$<br>$di/dt = 2.9\text{ A/nS}$ ,<br>$T_{vj} = 175^{\circ}\text{C}$ | –<br>–<br>– | 3<br>9<br>11         | –<br>–<br>– | mJ            |
| $Q_{RR}$ | Recovered Charge                 | $I_F = 600\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$V_{GE} = -8\text{ V}$ ,<br>$R_{g.on} = 4\ \Omega$ | $di/dt = 3.5\text{ A/nS}$ ,<br>$T_{vj} = 25^{\circ}\text{C}$<br>$di/dt = 3.0\text{ A/nS}$ ,<br>$T_{vj} = 150^{\circ}\text{C}$<br>$di/dt = 2.9\text{ A/nS}$ ,<br>$T_{vj} = 175^{\circ}\text{C}$ | –<br>–<br>– | 9<br>32<br>39        | –<br>–<br>– | $\mu\text{C}$ |
| $I_{rr}$ | Peak Reverse Recovery Current    | $I_F = 600\text{ A}$ , $V_R = 400\text{ V}$ ,<br>$V_{GE} = -8\text{ V}$ ,<br>$R_{g.on} = 4\ \Omega$ | $di/dt = 3.5\text{ A/nS}$ ,<br>$T_{vj} = 25^{\circ}\text{C}$<br>$di/dt = 3.0\text{ A/nS}$ ,<br>$T_{vj} = 150^{\circ}\text{C}$<br>$di/dt = 2.9\text{ A/nS}$ ,<br>$T_{vj} = 175^{\circ}\text{C}$ | –<br>–<br>– | 133<br>246<br>282    | –<br>–<br>– | A             |

## NTC SENSOR CHARACTERISTICS ( $T_{vj} = 25^{\circ}\text{C}$ , Unless Otherwise Specified)

| Symbol               | Parameters             | Conditions                                            | Min | Typ  | Max | Unit             |
|----------------------|------------------------|-------------------------------------------------------|-----|------|-----|------------------|
| $R_{25}$<br>(Note 3) | Rated Resistance       | $T_C = 25^{\circ}\text{C}$                            | –   | 5    | –   | $\text{k}\Omega$ |
| $\Delta R/R$         | Deviation of $R_{100}$ | $T_C = 100^{\circ}\text{C}$ , $R_{100} = 493\ \Omega$ | 5   | –    | 5   | %                |
| $P_{25}$             | Power Dissipation      | $T_C = 25^{\circ}\text{C}$                            | –   | –    | 20  | mW               |
| $B_{25/50}$          | B-Value                | $R = R_{25} \exp [B_{25/50} (1/T - 1/298)]$           | –   | 3375 | –   | K                |
| $B_{25/80}$          | B-Value                | $R = R_{25} \exp [B_{25/80} (1/T - 1/298)]$           | –   | 3360 | –   | K                |
| $B_{25/100}$         | B-Value                | $R = R_{25} \exp [B_{25/100} (1/T - 1/298)]$          | –   | 3364 | –   | K                |

## THERMAL CHARACTERISTICS

| Symbol             | Parameter                                                                | Min | Typ   | Max  | Unit                 |
|--------------------|--------------------------------------------------------------------------|-----|-------|------|----------------------|
| $IGBT.R_{th,J-F}$  | $R_{th}$ , Junction to Fluid, 10 L/min, $65^{\circ}\text{C}$ , 50/50 EGW | –   | 0.083 | 0.10 | $^{\circ}\text{C/W}$ |
| $Diode.R_{th,J-F}$ | $R_{th}$ , Junction to Fluid, 10 L/min, $65^{\circ}\text{C}$ , 50/50 EGW | –   | 0.134 | 0.16 | $^{\circ}\text{C/W}$ |

## ORDERING INFORMATION

| Part Number    | Package                                | Shipping       |
|----------------|----------------------------------------|----------------|
| NVH950S75L4SPC | SSDC33, 154.50x92.0 (SPC)<br>(Pb-Free) | 4 Units / Tray |

TYPICAL CHARACTERISTICS

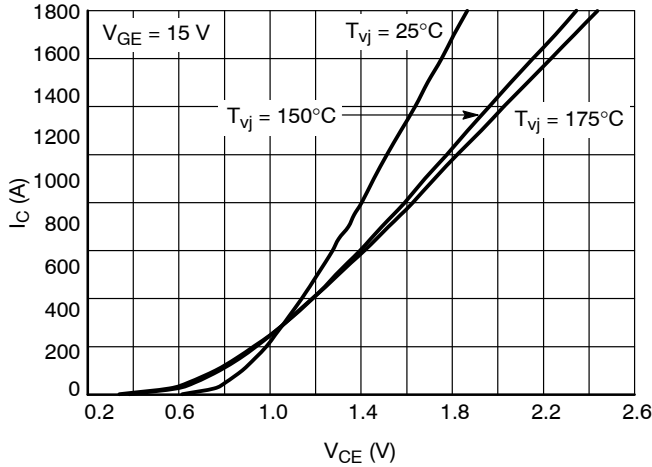


Figure 2. IGBT Output Characteristic

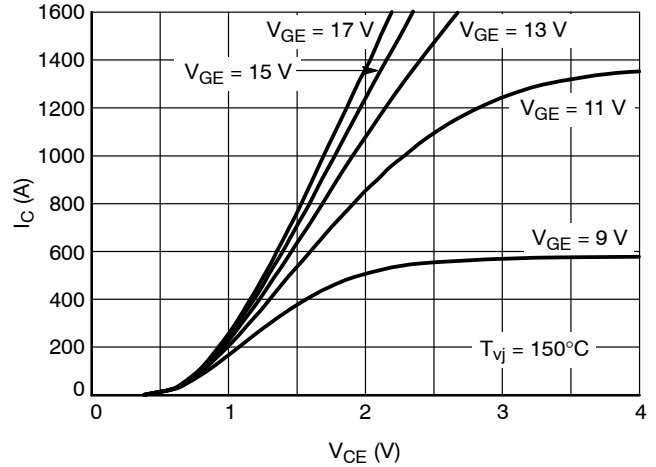


Figure 3. IGBT Output Characteristic

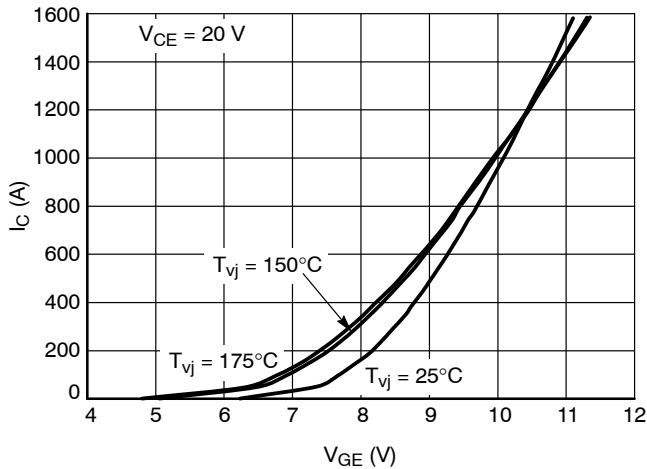


Figure 4. IGBT Transfer Characteristic

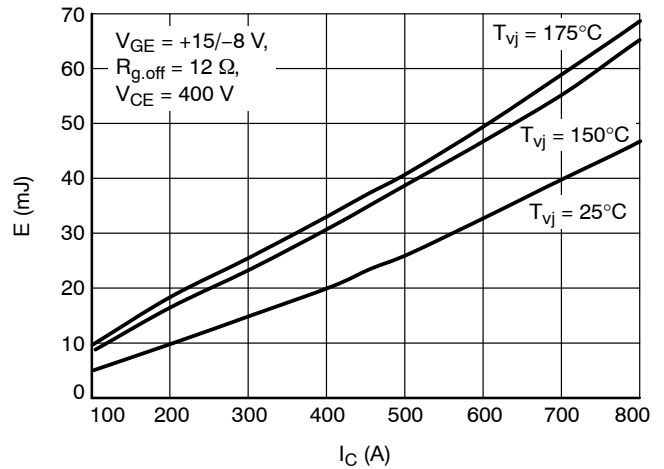


Figure 5. IGBT Turn-off Losses vs.  $I_C$

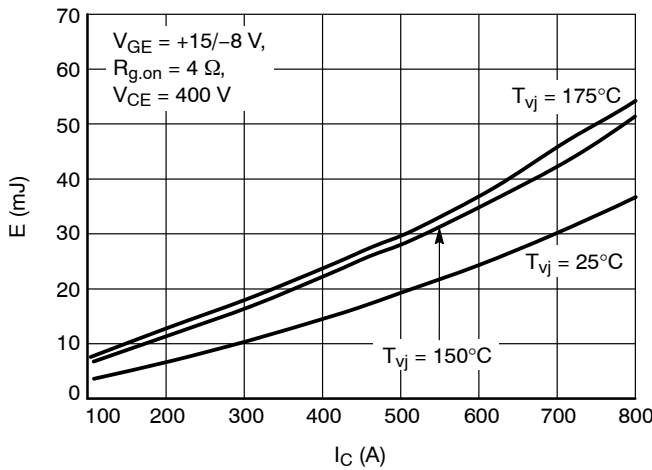


Figure 6. IGBT Turn-on Losses vs.  $I_C$

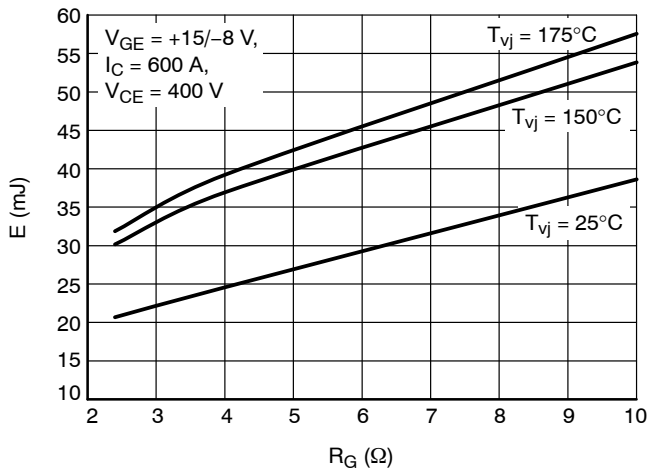


Figure 7.  $E_{ON}$  vs.  $R_G$

TYPICAL CHARACTERISTICS

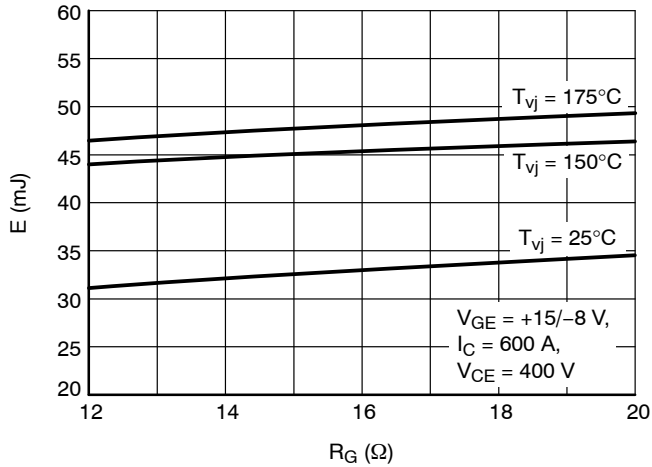


Figure 8.  $E_{OFF}$  vs.  $R_G$

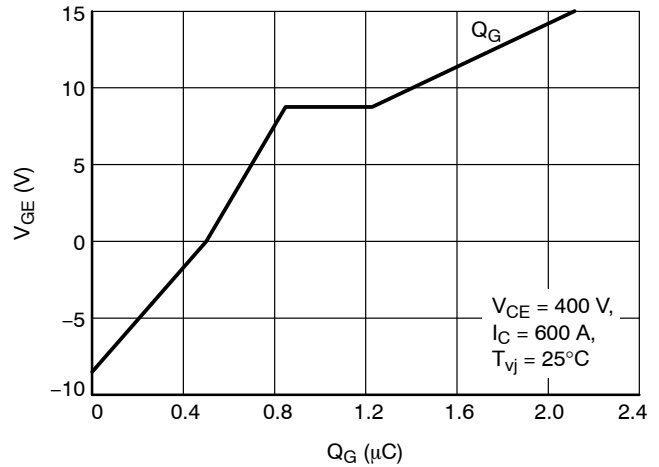


Figure 9. Gate Charge Characteristic

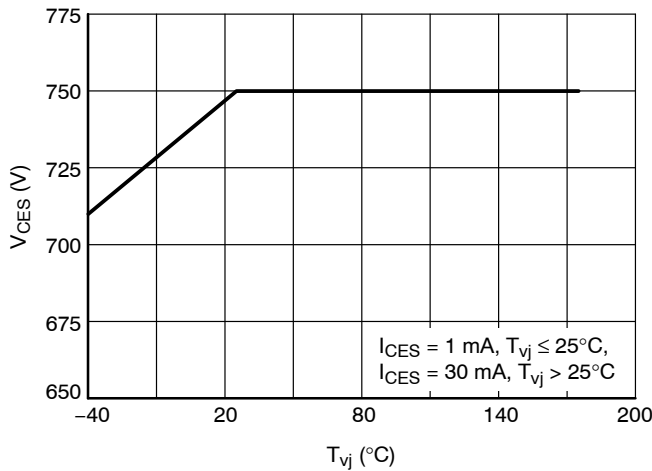


Figure 10. Maximum Allowed  $V_{CE}$

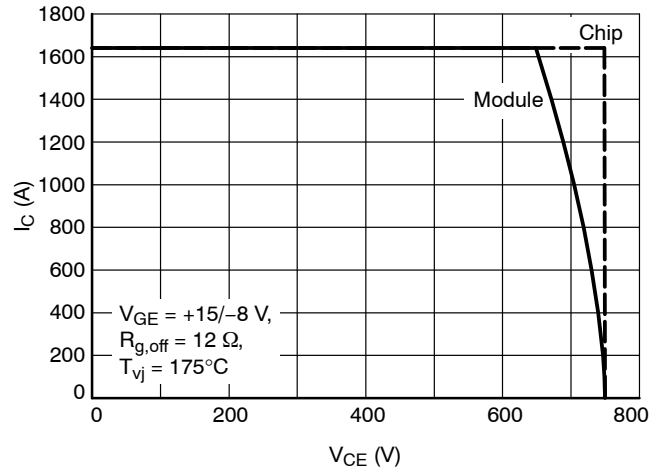


Figure 11. Reverse Bias Safe Operating Area

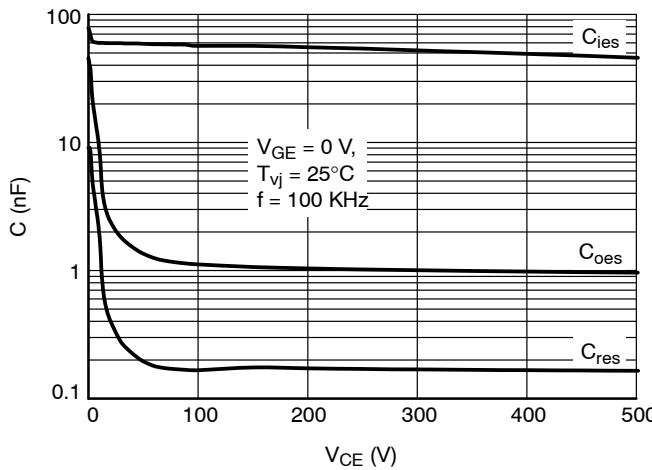


Figure 12. Capacitance Characteristic

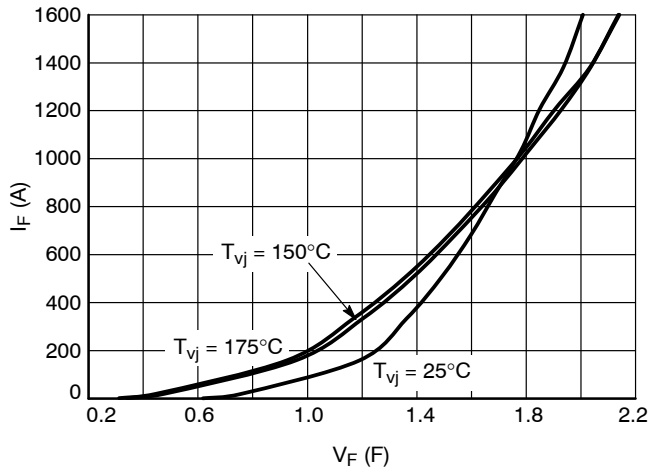


Figure 13. Diode Forward Characteristic

TYPICAL CHARACTERISTICS

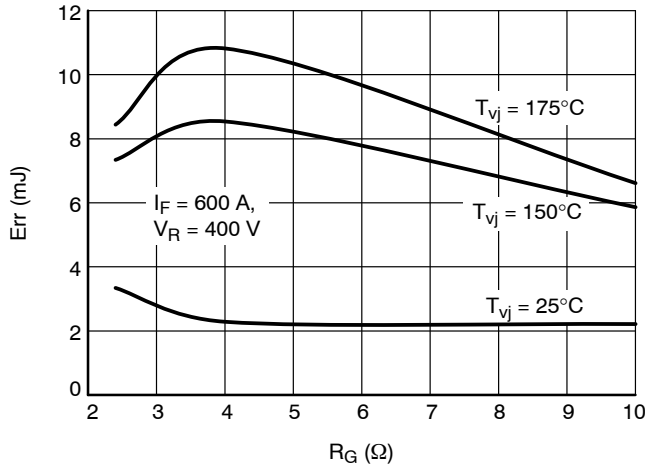


Figure 14. Diode Switching Losses vs.  $R_G$

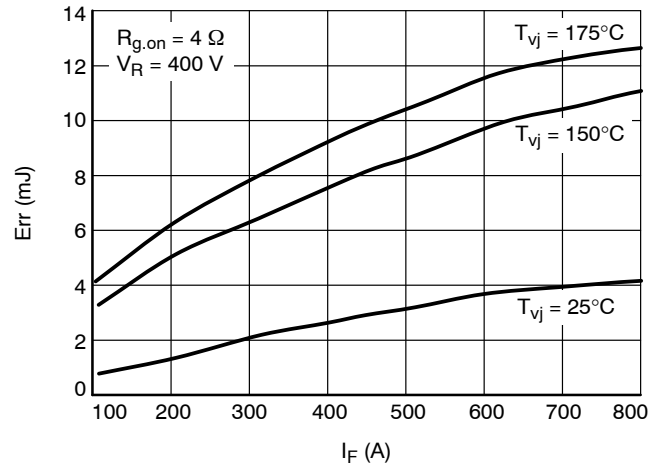


Figure 15. Diode Switching Losses vs.  $I_F$

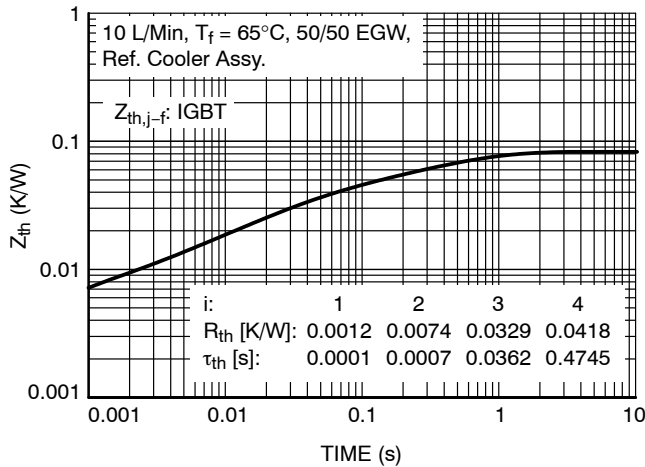


Figure 16. IGBT Transient Thermal Impedance (Typ.)

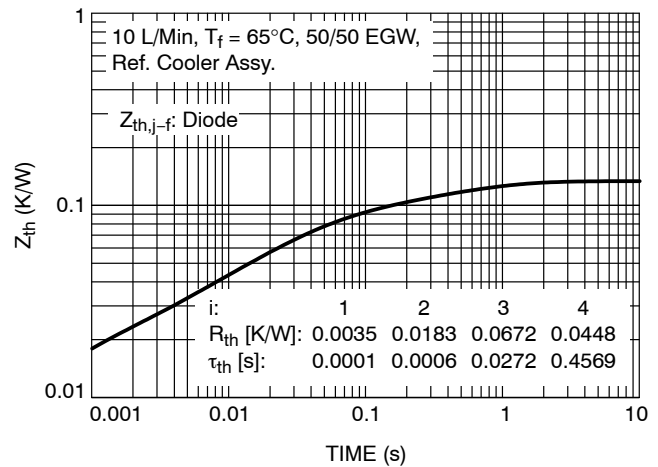


Figure 17. Diode Transient Thermal Impedance (Typ.)

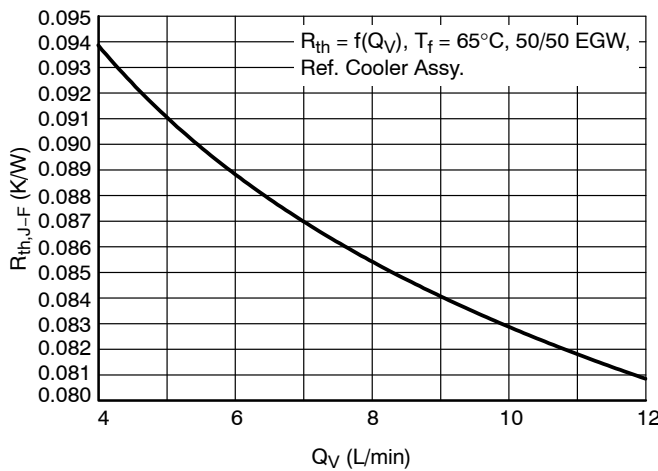


Figure 18. IGBT, Thermal Resistance (Typ.)

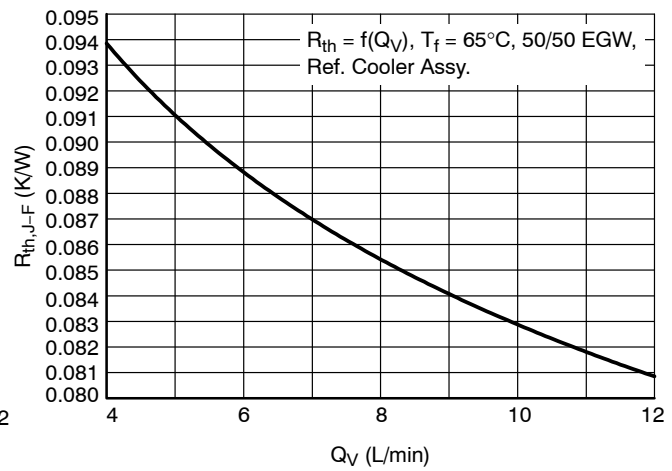


Figure 19. Diode, Thermal Resistance (Typ.)



TYPICAL CHARACTERISTICS

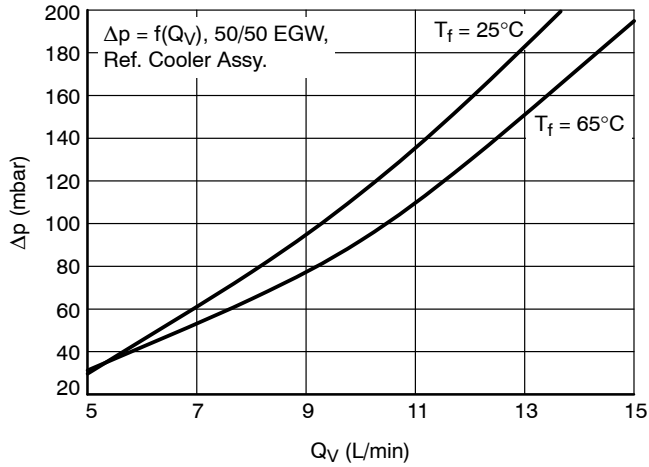


Figure 20. Pressure Drop in Cooling Circuit

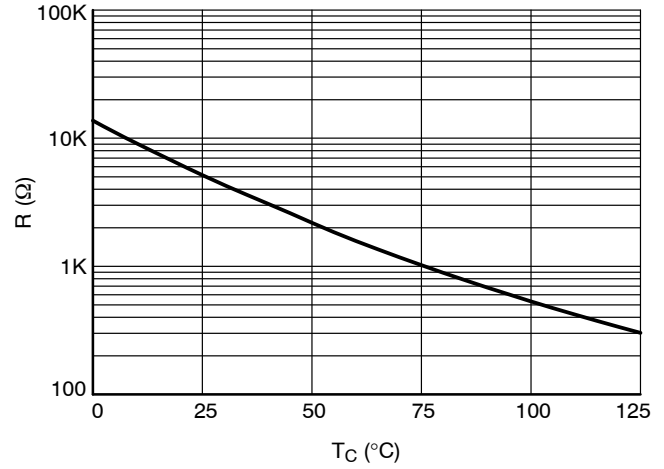
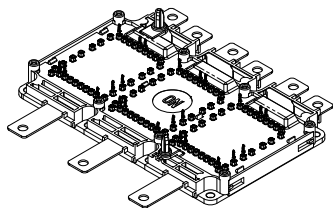


Figure 21. NTC Thermistor – Temperature Characteristic (Typical)

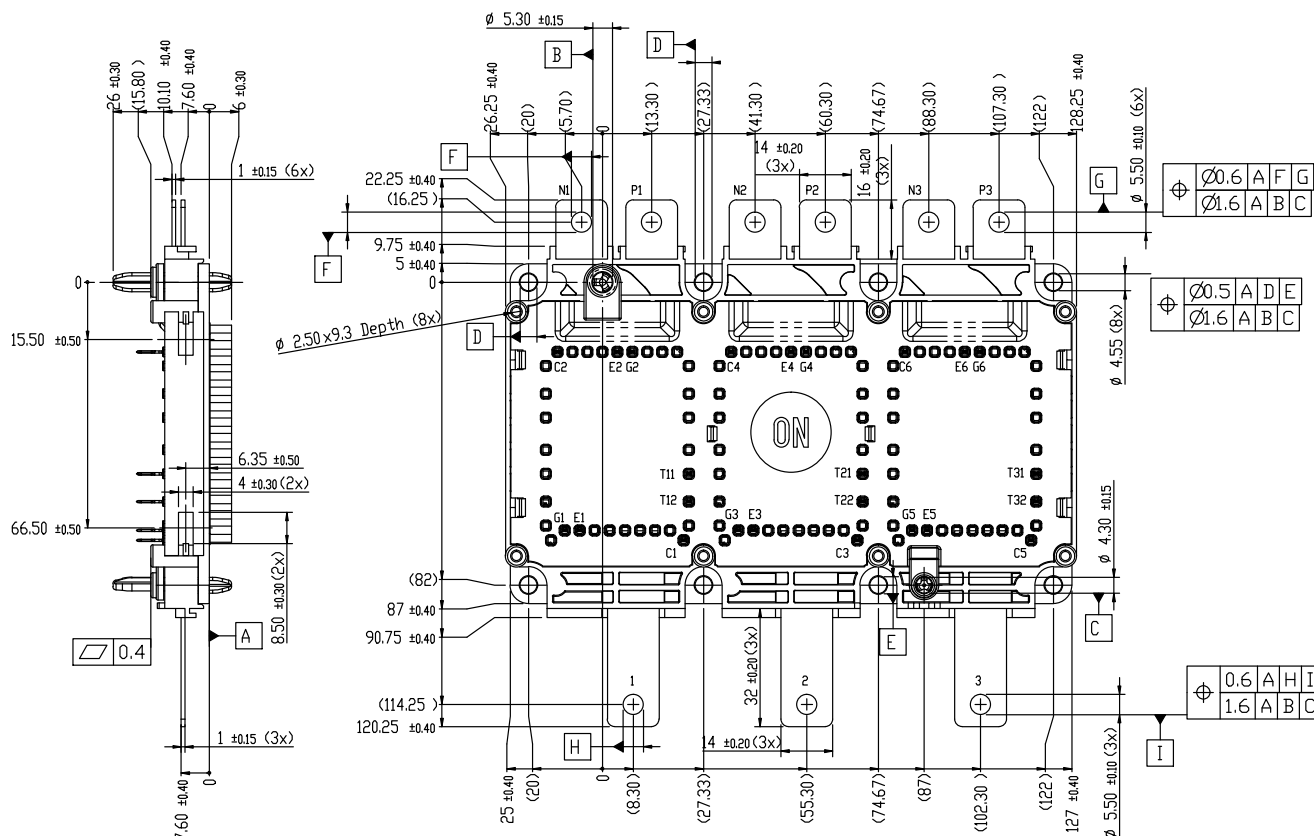
# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

ON Semiconductor®



**SSDC33, 154.50x92.0 (SPC)**  
**CASE 183AC**  
**ISSUE A**

DATE 11 DEC 2019



## GENERIC MARKING DIAGRAM\*

XXXXXXXXXXXXXXXXXXXXXG  
ATYYWW

XXXXX = Specific Device Code  
G = Pb-Free Package  
AT = Assembly & Test Site Code  
YYWW= Year and Work Week Code

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

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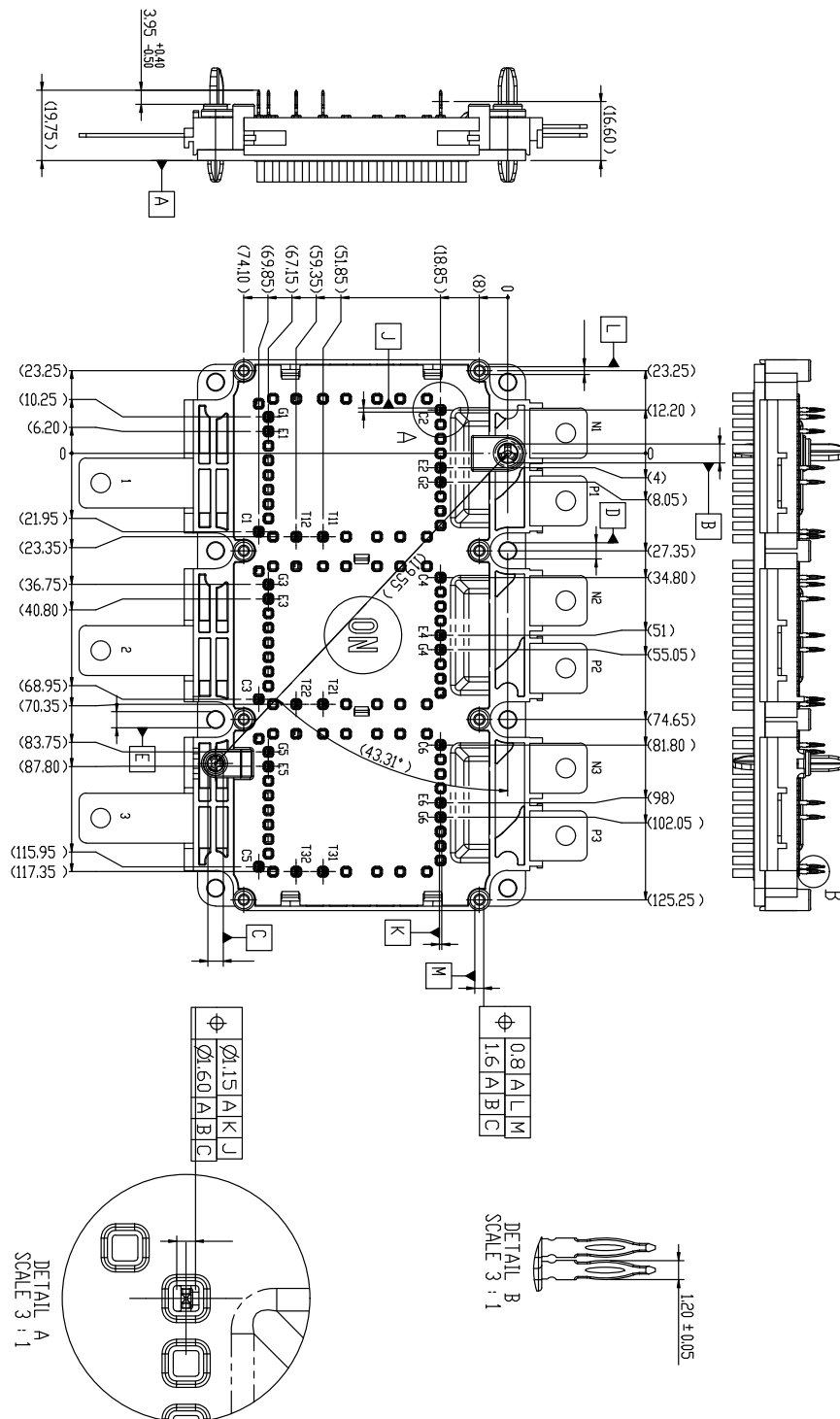
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